HYDROGEN STATION, AND PROCESS FOR OPERATING THE SAME

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

[0001] The present invention relates to a hydrogen station, e.g., a hydrogen station designed to produce, store and supply hydrogen in order to dispense the hydrogen to a vehicle using a fuel cell as a drive source, and a process for operating the hydrogen station.

DESCRIPTION OF THE RELATED ART

[0002] There has been conventionally developed a technique in which a reformer is mounted as a hydrogen supply source in a vehicle using a fuel cell as a drive source.

[0003] However, the reformer suffers from the following problem: The reformer is poor in responsiveness, because a predetermined time is required until the reformer reaches a steady operation from the start thereof. If an auxiliary means is provided to attempt to alleviate the problem the hydrogen supply equipment becomes complicated.

[0004] To solve the above problem, it is considered that a large number of hydrogen stations are disposed dispersedly throughout an entire country so that hydrogen is available to be supplied to a hydrogen storage tank mounted in a vehicle from each of the hydrogen stations.

SUMMARY OF THE INVENTION

[0005] Accordingly, it is an object of the present invention to provide a hydrogen station of the above-described type, which is convenient and useful, based on the above consideration.

[0006] To achieve the above object, according to an embodiment of the present invention, there is provided a hydrogen station comprising a water electrolyzer for producing hydrogen containing moisture, a dewatering device capable of capturing the moisture from the

hydrogen to provide the hydrogen in a dry state, a tank for storage of the hydrogen in the dry state, a new dewatering device adapted to replace the dewatering device when the function of the latter dewatering device has declined with an increase in amount of moisture captured, and regenerating equipment for regenerating the original dewatering device after being replaced, thereby recovering the water-capturing ability thereof. The regenerating equipment has a function of heating the original dewatering device to evaporate the captured moisture, a function of permitting the regenerating hydrogen in the dry state to flow into the original dewatering device and permitting regenerating hydrogen containing the moisture to flow out of the original dewatering device, and a function of removing the moisture from the regenerating hydrogen to provide regenerating hydrogen in a dry state.

[0007] If the water electrolyzer for producing the hydrogen is provided as described above, labor and cost for transporting hydrogen from another place can be saved. In addition, it is possible to efficiently carry out the replacement and regeneration of the dewatering device to ease the transition from the production of the hydrogen to the storage of the hydrogen.

[0008] If such hydrogen stations are disposed dispersedly throughout the whole country, a problem of infrastructure, which is a large impediment to the widespread use of vehicles provided with a fuel cell, can be overcome. Thus, the hydrogen station is convenient and useful, and can contribute greatly to the acceptance of a vehicle provided with a fuel cell.

[0009] It is another object of the present invention to provide a process for operating a hydrogen station, which is economical and constructed so that not only electric power required for the electrolysis of water but also electric power for regenerating the dewatering device can be supplied by a photovoltaic generator.

[0010] To achieve the above object, according to the present invention, there is provided a process for operating a hydrogen station comprising a photovoltaic generator, an external power supply, a water electrolyzer for producing hydrogen containing moisture by use of an

electric power supplied from the photovoltaic generator, a plurality of dewatering devices capable of capturing the moisture from the hydrogen to provide hydrogen in a dry state, a tank for storage of the hydrogen in the dry state, and regenerating equipment adapted so that one of an electric power from the photovoltaic generator and both the electric power from the photovoltaic generator and electric power from the external power supply is supplied to the regenerating equipment, when the function of the dewatering device has been reduced with an increase in amount of moisture captured, thereby regenerating the dewatering device to recover the water-capturing ability thereof. The process comprises the step of estimating a power-generating time and an amount of electric power generated in the photovoltaic generator, whereby when the water electrolysis and the regeneration of the dewatering device can be carried out in parallel to each other by use of the electric power from the photovoltaic generator, they are carried out, or when neither of the water electrolysis nor the regeneration of the dewatering device can be carried out by use of the electric power from the photovoltaic generator, if there is only at least one of the dewatering devices having the water-capturing ability, the regeneration of the dewatering device required to be regenerated is carried out using both the electric power from the photovoltaic generator and the electric power from the external power source in combination.

[0011] With the above process, the above-mentioned object is achieved.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The above and other objects, features and advantages of the invention will become apparent from the following description of the preferred embodiment taken in conjunction with the accompanying drawings, in which:

[0013] Fig. 1 is a schematic diagram showing a hydrogen station in accordance with an embodiment of this invention; and

[0014] Fig. 2 is a flow chart for regenerating a dewatering device in accordance with the embodiment of this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0015] The present invention will now be described by way of an embodiment of the present invention with reference to the accompanying drawings.

[0016] Referring to Fig. 1, in a hydrogen station 1, a water electrolyzer 4 is connected to a photovoltaic generator 2 as a power supply through a first feeder 31. A dewatering device 6 is connected at the inlet side to a hydrogen-releasing side of the water electrolyzer 4 through a supply pipe 5 and at the outlet side to a tank 8 through a supply pipe 7. The dewatering device 6 can be filled with a synthetic zeolite. The synthetic zeolite can have a high water-capturing ability and a high stability.

[0017] In the above arrangement, the photovoltaic generator 2 receives sunrays to generate electric power, which is supplied to the water electrolyzer 4, thereby operating the water electrolyzer 4 to produce hydrogen. Such hydrogen contains moisture, but the moisture is captured by the dewatering device 6, whereby the hydrogen is brought into a dry state. The hydrogen in the dry state is introduced into and stored in the tank 8. A metal hydride as a hydrogen-absorption material can be accommodated in the tank 8. Otherwise, the tank 8 may have a pressure-proof structure in order to store high-pressure hydrogen compressed by a compressor 40. The use of the photovoltaic generator 2 as the power supply for the water electrolysis as described above is effective for providing a reduction in cost for production of hydrogen.

[0018] As the amount of moisture captured by the dewatering device 6 is increased, the function of the dewatering device 6 is correspondingly reduced. In this case, the dewatering device 6, whose function has been reduced and which is in operation, can be replaced by a

new dewatering device 6' having a water-capturing ability. The dewatering device 6 now referred to as original dewatering device 6" after being replaced by the new dewatering device 6' is subjected to a regeneration, whereby the water-capturing ability thereof is recovered.

[0019] Regenerating apparatus 9 includes an electric heater 10 for the dewatering device, a hydrogen-circulating system 11 for permitting regenerating hydrogen to flow to the original dewatering device 6" and a condenser 12 mounted in the hydrogen-circulating system 11. The hydrogen-circulating system 11 includes a circulation passage 13 through which the regenerating hydrogen flows, and a circulating pump 14 mounted in the circulation passage 13. The original dewatering device 6" and the condenser 12 can be placed in the circulation passage 13.

[0020] Lead wires 15, 16 and 17 from the electric heater 10, the condenser 12 and the circulating pump 14 are connected to an external electric supply 18 through a second feeder 32. The second feeder 32 is connected at its intermediate portion to the photovoltaic generator 2 through a conductive wire 19, and a first switch 21 is mounted in the conductive wire 19. In the second feeder 32, a second switch 22 is mounted between the external power supply 18 and a connection of the conductive wire 19. Hydrogen produced by the water electrolyzer 4 can be used as the regenerating hydrogen.

[0021] To regenerate the original dewatering device 6" replaced, the first switch 21 is opened, and the second switch 22 is closed, whereby the original dewatering device 6" is heated by the electric heater 10 to evaporate the captured water. The regenerating hydrogen in the dry state is permitted to flow into the original dewatering device 6" by operating the circulating pump 14, and the regenerating hydrogen containing the moisture (vapor) is permitted to flow out of the dewatering device 6". The moisture is removed from the regenerating hydrogen by the condenser 12 to provide the regenerating hydrogen in the dry

state, which is then permitted to flow into the original dewatering device 6". The moisture is removed from the original dewatering device 6" by such circulation of the hydrogen, whereby the water-capturing ability is sufficiently recovered, and the regenerating operation is finished.

[0022] If the hydrogen is used to remove the moisture in the original dewatering device 6" replaced, as described above, even if such hydrogen remains in the new dewatering device 6' after regeneration, the remaining hydrogen cannot cause a problem in the subsequent water-removing course.

[0023] To supply the electric power for generating the dewatering device 6 to the utmost by the photovoltaic generator 2 to suppress the need to use the external power supply, the following measure can be employed.

[0024] The capacity of the dewatering device 6 for capturing the moisture is set to exceed an amount of moisture captured based on the amount of hydrogen produced during an entire day. The dewatering device 6 can be replaced about once a day, and three dewatering devices 6, 6' and 6" are mounted in the hydrogen station.

[0025] In Fig. 1, one of the two regenerated dewatering devices 6 is in an operable state in which it has been connected to the water electrolyzer 4 and the tank 8 through the supply pipes 5 and 7, and the other dewatering device 6' is on standby for replacement. The remaining one dewatering device 6" is in the circulation passage 13 of the regenerating equipment 9, because the amount of moisture captured has reached a limit.

[0026] To operate the hydrogen station 1 in the morning, the power-generating time and the amount of power generated in that day are first estimated based on at least one of average insolation amount and insolation time per day over several past years, the weather forecast for that day and information provided when an atmospheric pressure sensor is placed in the hydrogen station 1, as shown in Fig. 2.

[0027] When the weather on that day is good, and it has been predicted that the water electrolysis and the regeneration of the dewatering device 6" can be carried out in parallel to each other by use of the electric power from the photovoltaic generator 2, the regeneration of the dewatering device is started along with the water electrolysis by closing the first switch 21 and opening the second switch 22.

[0028] After the start of the regeneration, the regeneration of the dewatering device 6" using the electric power from the photovoltaic generator 2 is continued to reach the completion of the regeneration, if the fine weather is continued. On the other hand, when the electric power from the photovoltaic generator 2 is sufficient to carry out the water electrolysis, but insufficient to carry out the regeneration of the dewatering device 6" in parallel to the water electrolysis due to a variation in weather after the start of the regeneration, the second switch 22 is closed, and both the electric power from the external power supply 18 and the electric power from the photovoltaic generator 2 are used to continue the regeneration until the regeneration is complete. When the supply of the electric power from the photovoltaic generator 2 runs out, the regeneration of the dewatering device is carried out by use of the electric power from the external power supply 18.

[0029] When the weather is not fine in the morning and it is predicted that it is impossible to carry out the water electrolysis by use of the electric power from the photovoltaic generator 2, there are the two regenerated dewatering devices 6 and 6' capable of being used to produce hydrogen on the next day, namely, the two regenerated dewatering devices 6 and 6' having the water-adsorbing ability and hence, these dewatering devices 6 and 6' are left on standby to expect that the next day's weather will be fine. On the other hand, if the three dewatering devices 6, 6' and 6" are required to be regenerated due to a mistake in the operation, both the electric power from the photovoltaic generator 2 and the electric power from the external power supply 18 are used with the first and second switches 21 and 22

closed, thereby carrying out the regeneration of at least one of the dewatering devices. When the supplying of the electric power from the photovoltaic generator 2 runs out, the regeneration of the dewatering device is carried out by use of the electric power from the external power supply 18. A pressure-proof tank having no hydrogen-absorption material may be used as the tank 8 in order that hydrogen in a dry state passed through the dewatering device 6 is compressed by the compressor 40 and charged into the pressure-proof tank.

[0030] The arrangement may be such that the electric heater 10, the condenser 12 and the circulating pump 14 can be connected individually to the photovoltaic generator 2, so that the power from the photovoltaic generator 2 can be selectively supplied to the electric hater 10 and the like. An aerogenerator may be used as the power supply for the water electrolyzer 4.

[0031] According to the present invention, with the above-mentioned structure, there is provided a hydrogen station which is convenient and useful, and can contribute greatly to the spreading of a vehicle provided with a fuel cell.

[0032] According to the present invention, by employing the above-mentioned process, there is provided a process for operating a hydrogen station, which is economical and constructed so that not only electric power required for the electrolysis of water but also electric power for regenerating the dewatering device can be supplied by a photovoltaic generator.

[0033] Although embodiments of the present invention have been described in detail, it will be understood that the present invention is not limited to the above-described embodiments, and various modifications in construction may be made without departing from the spirit and scope of the invention defined in the following claims.